Overview of NJDOT HRAP Specification

NJ Asphalt Paving Conference

2/27/15

Overview

- NJDOT HRAP Specification Review
- Why Selection of Overlay Tester
- Things to Do to Make My Mix Pass
- Questions

NJDOT HRAP Specification

NJDOT HRAP – Basic Principle

- The supplier is not held to PG grade, max. RAP content, aggregate angularity, etc.
  - Have to meet basic Superpave requirements
  - NJDOT increased VMA 1% over current specs
  - Could use softer binder, rejuvenators, WMA
- However, acceptance based on final mixture performance, based on database of typical "virgin" HMA

NJDOT HRAP - Volumetrics

Table 902.11.03-1 HMA HIGH RAP Requirements for Design

Compaction Levels	Required Density (% of Theoretical Max. Specific Gravity)		Voids in Mineral Aggregate (VMA)[2], % (minimum)					Voids Filled With Asphalt (VFA) %	Dust-to-Binder Ratio
			Nominal Max. Aggregate Size, mm						
	$@N_{des}$[1]	$@N_{max}$	25.0	19.0	12.5	9.5	4.75		
L	96.0	≤ 98.0	13.0	14.0	15.0	16.0	17.0	70 - 85	0.6 - 1.2
M	96.0	≤ 98.0	13.0	14.0	15.0	16.0	17.0	65 - 85	0.6 - 1.2

1. As determined from the values for the maximum specific gravity of the mix and the bulk specific gravity of the compacted mixture. Maximum specific gravity of the mix is determined according to AASHTO T 209. Bulk specific gravity of the compacted mixture is determined according to AASHTO T 166. For verification, specimens must be between 95.0 and 97.0 percent of maximum specific gravity at N_{des}.
2. For calculation of VMA, use bulk specific gravity of the combined aggregate including aggregate extracted from the RAP.

Table 902.11.04-1 HMA HIGH RAP Requirements for Control

Compaction Levels	Required Density (% of Theoretical Max. Specific Gravity)	Voids in Mineral Aggregate (VMA), % (minimum)					Dust-to
		Nominal Max. Aggregate Size, mm					
	@Ndes[1]	25.0	19.0	12.5	9.5	4.75	Binder Ra
L, M	95.0 – 98.5	13.0	14.0	15.0	16.0	17.0	0.6 - 1.3

1. As determined from the values for the maximum specific gravity of the mix and the bulk specific gravity of the compa mixture. Maximum specific gravity of the mix is determined according to AASHTO T 209. Bulk specific gravity of compacted mixture is determined according to AASHTO T 166.

NJDOT HRAP - Performance

- Minimum of 20% RAP in Surface Course
- Minimum of 30% RAP in Intermediate/Base
- Lab design and plant produced material must meet rutting (APA) and cracking (Overlay Tester) requirements

Table 902.11.03-2 Performance Testing Requirements for HMA HIGH RAP Design				
Test	Requirement			
	Surface Course		Intermediate Course	
	PG 64-22	PG 76-22	PG 64-22	PG 76-22
APA @ 8,000 loading cycles (AASHTO T 340)	< 7 mm	< 4 mm	< 7 mm	< 4 mm
Overlay Tester (NJDOT B-10)	> 150 cycles	> 175 cycles	> 100 cycles	> 125 cycles

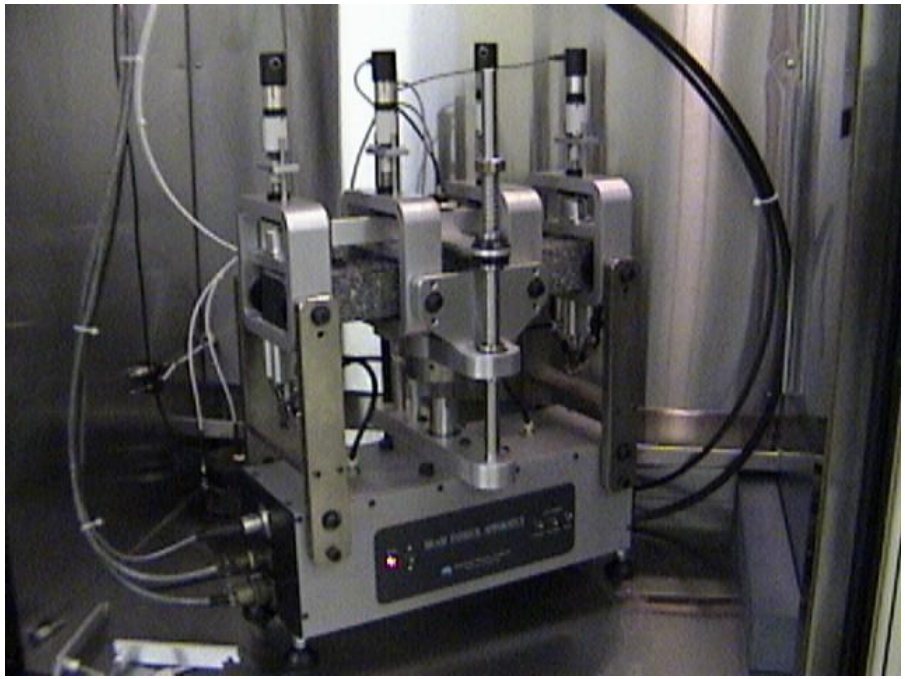
Why Overlay Tester for Fatigue?

Conflicting Information (?)

- Tons of literature illustrating conflicting information pertaining to the fatigue cracking performance of recycled asphalt mixtures
- Question is why?
  - Differences in regional materials
  - Differences in regional climate
  - Differences in production practices
  - **Differences in what we define as fatigue cracking performance (lab vs field)**

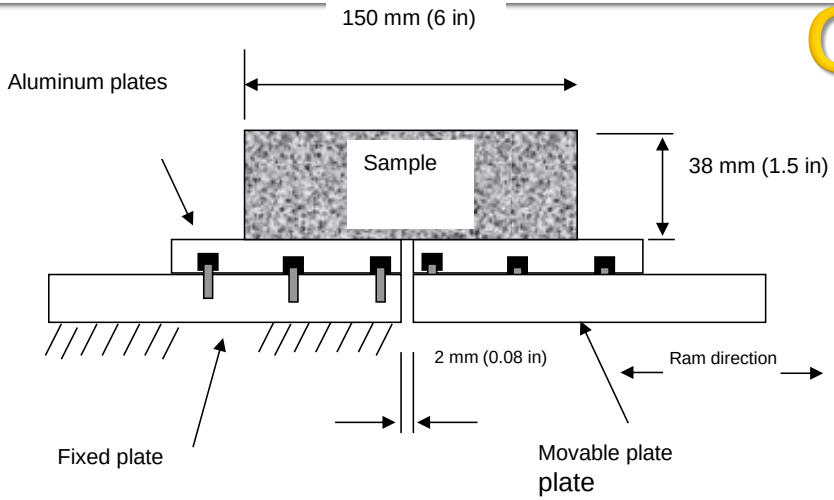
Crack Initiation Test

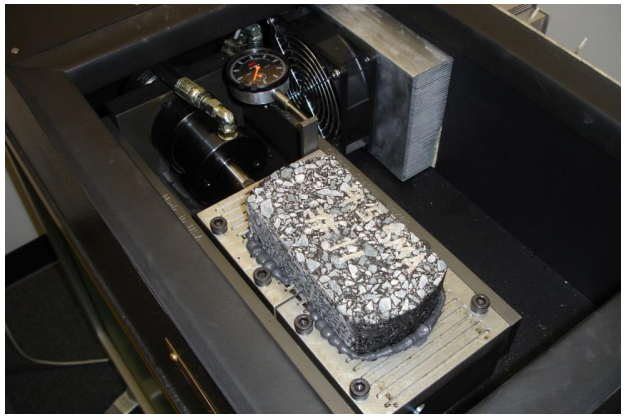
- Flexural Beam Device, AASHTO T321
- Test mixes ability to withstand repeated bending
- Run at strain levels higher than expected field strains to accelerate testing



Crack Propagation

Overlay Tester



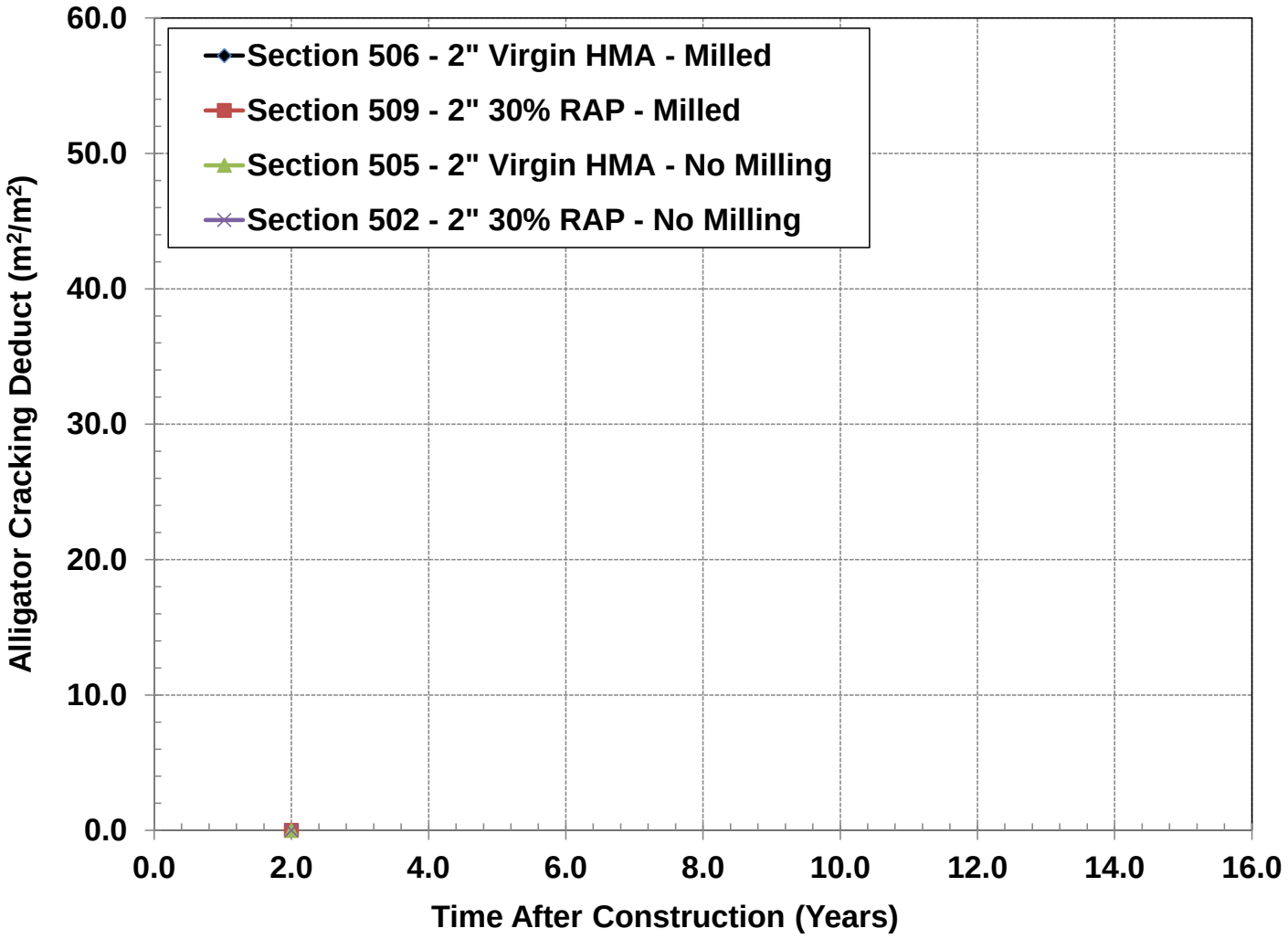


- Sample size: 6″ long by 3″ wide by 1.5″ high
- Loading: Continuously triangular displacement 5 sec loading and 5 sec unloading
- Definition of failure
  - Discontinuity in Load vs Displacement curve

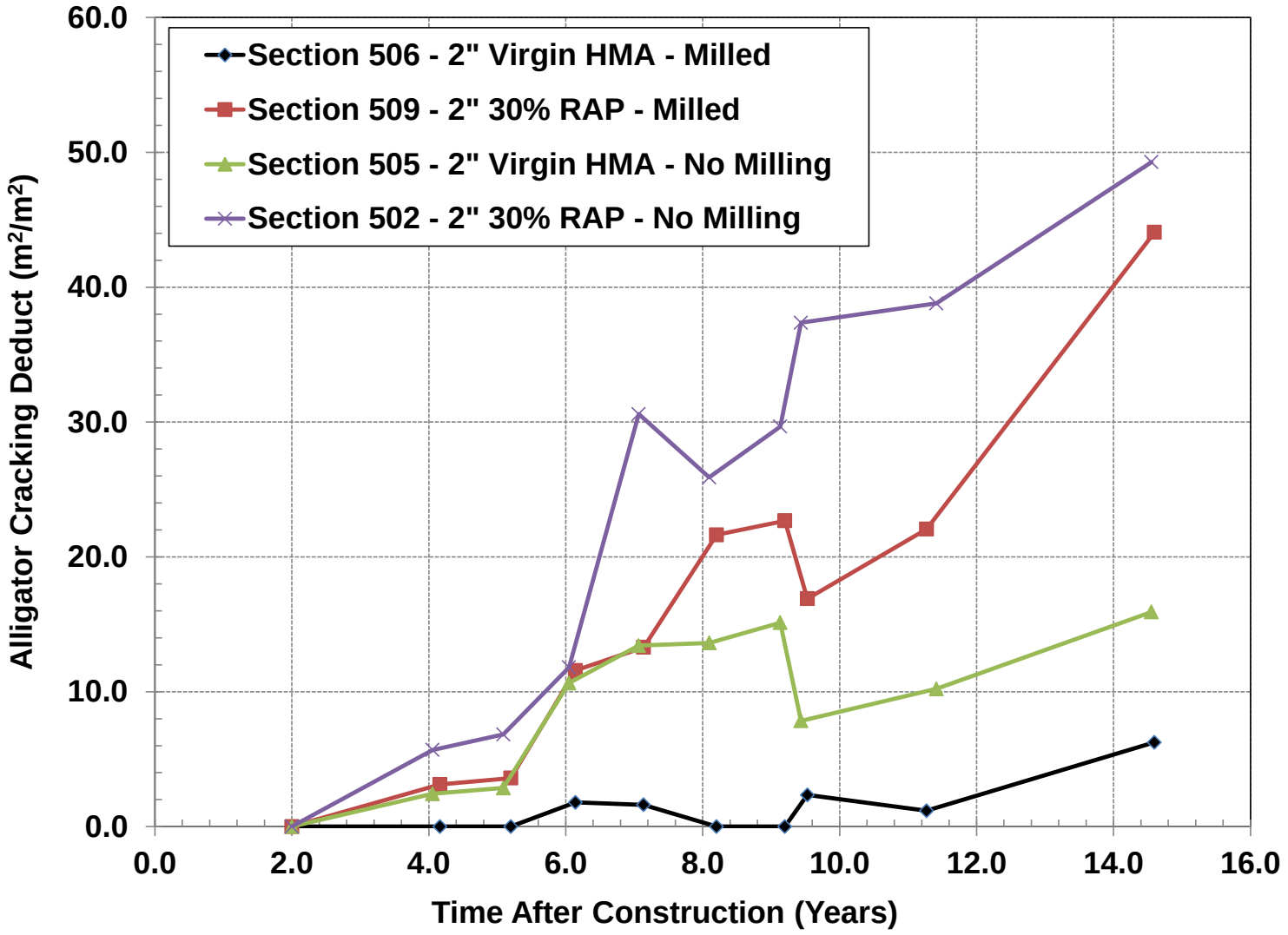
Example of Importance on How We Measure Cracking

- SPS-5 (LTPP's Special Pavement Sections) used for the "Study of Rehabilitation of Asphalt Concrete Mixtures"
  - 2-inch vs 5-inch thick overlays
  - Milled vs Unmilled surfaces
  - Virgin vs 30% RAP Mixtures
- NJ Constructed in 1994 – Out of Service in 2009
- Yearly distress survey
- Cores taken and tested prior to rehab, as well as retained loose mix from 1994 construction

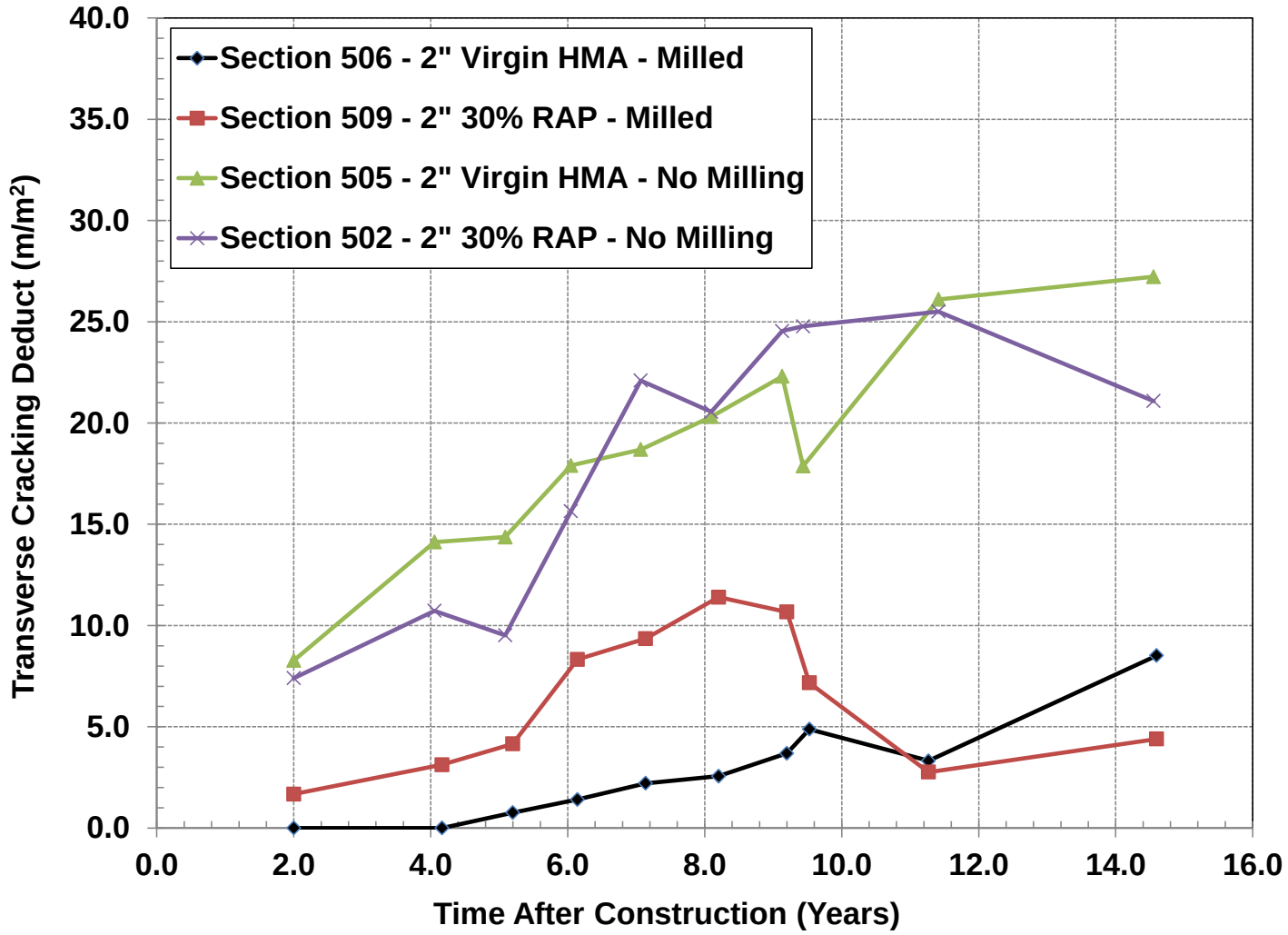
NJ SPS-5 Alligator Cracking - Initiation



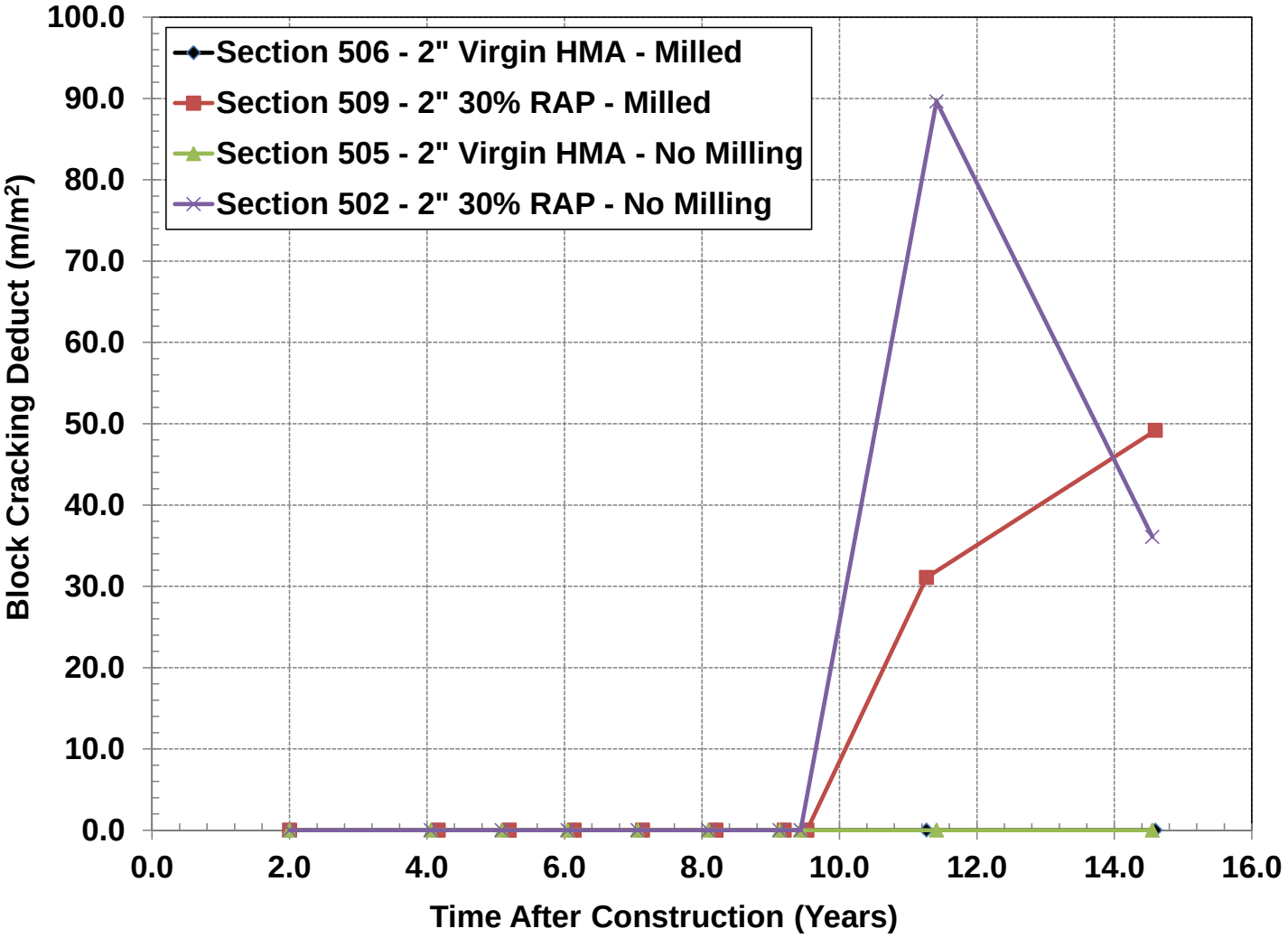
NJ SPS-5 Alligator Cracking – Final (Propagation)



NJ SPS-5 Transverse Cracking – Final



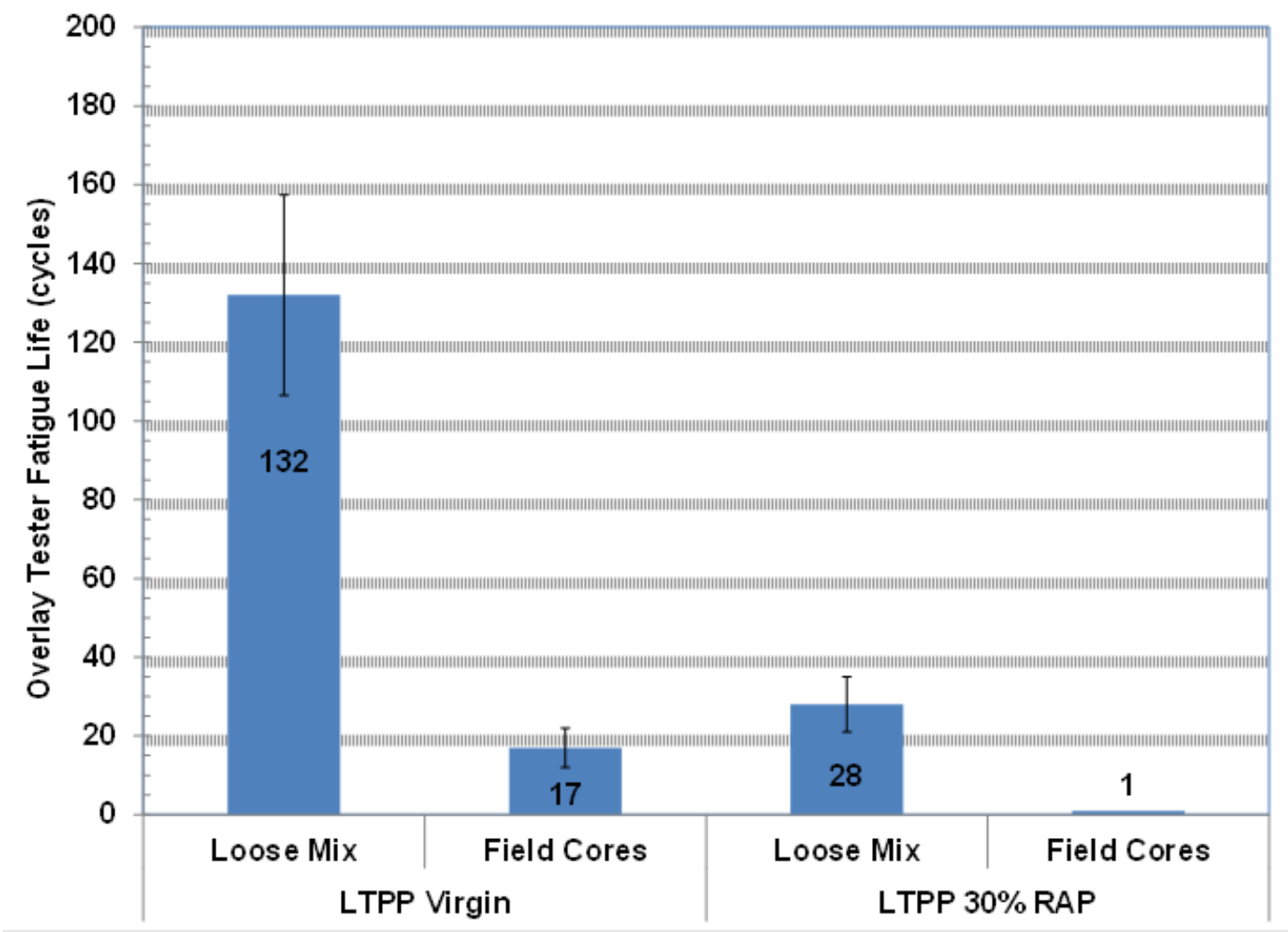
NJ SPS-5 Block Cracking – Final



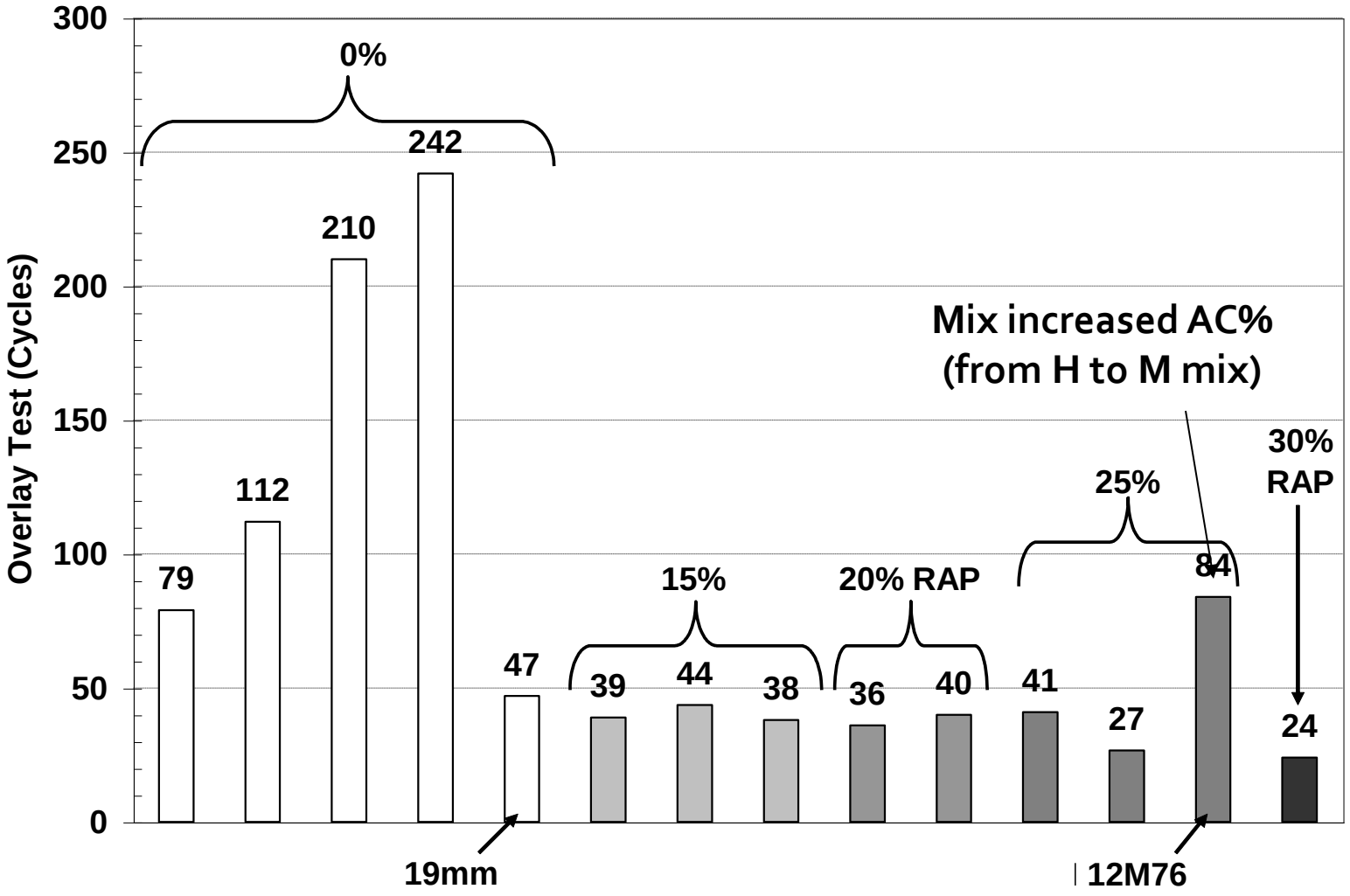
NJ SPS-5 Field Initiation vs Propagation

- Sections began to have "measurable" Alligator Cracking around the same time period
- However, once cracking had initiated, the cracking propagated through the RAP sections at a greater rate
- Therefore, crack initiation rankings appear to differ from crack propagation rankings

Initiation vs Propagation – Overlay Tester for NJ SPS-5



Overlay Tester – 2008 to 2009



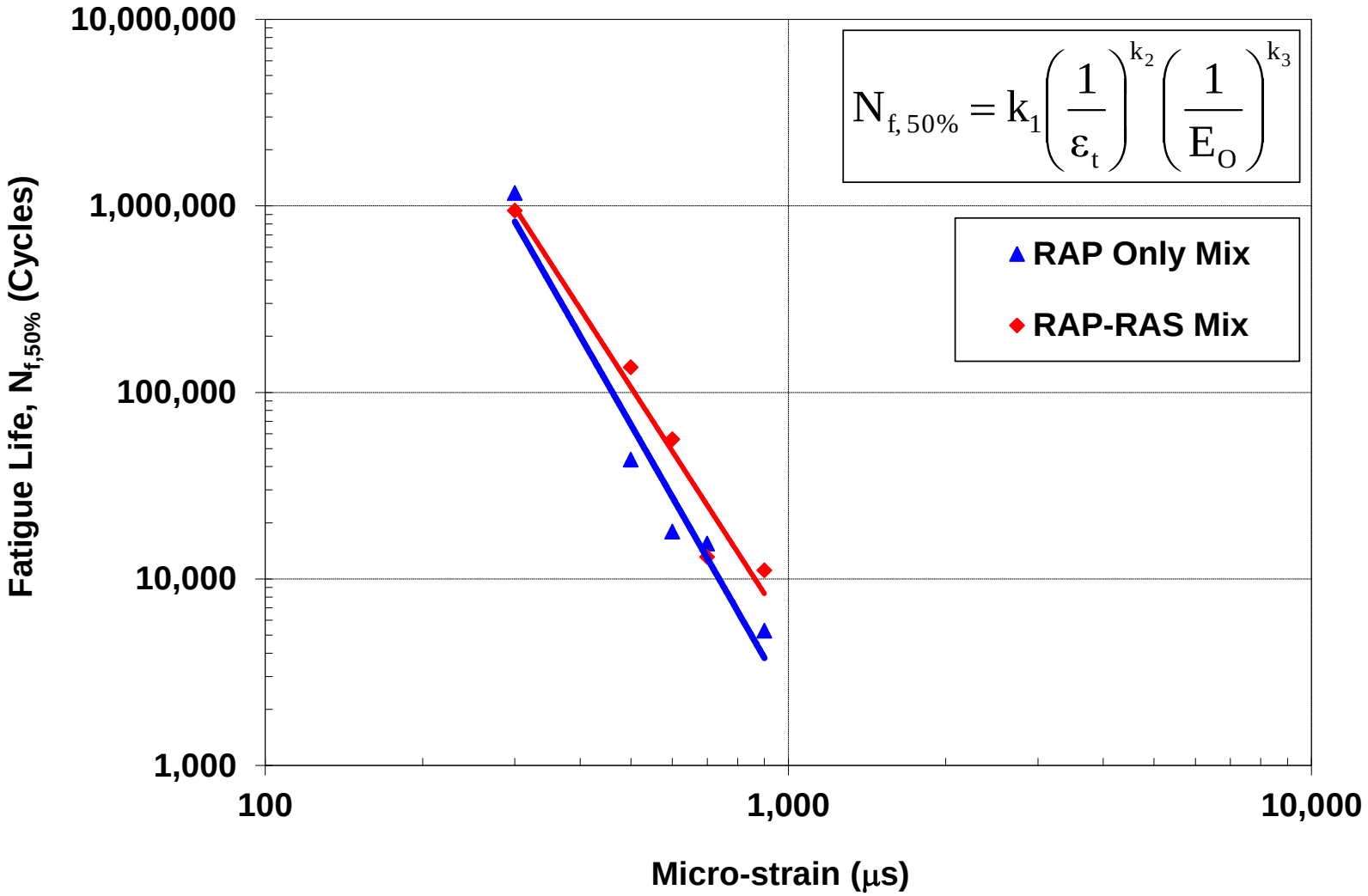
Average Results for Overlay Tester (2008 to 2009)

- 0% RAP = 138 cycles
- 15% RAP = 40 cycles
- 20% RAP = 38 cycles
- 25% RAP = 40 cycles
- 30% RAP = 24 cycles (only 1 mix – 19mm)

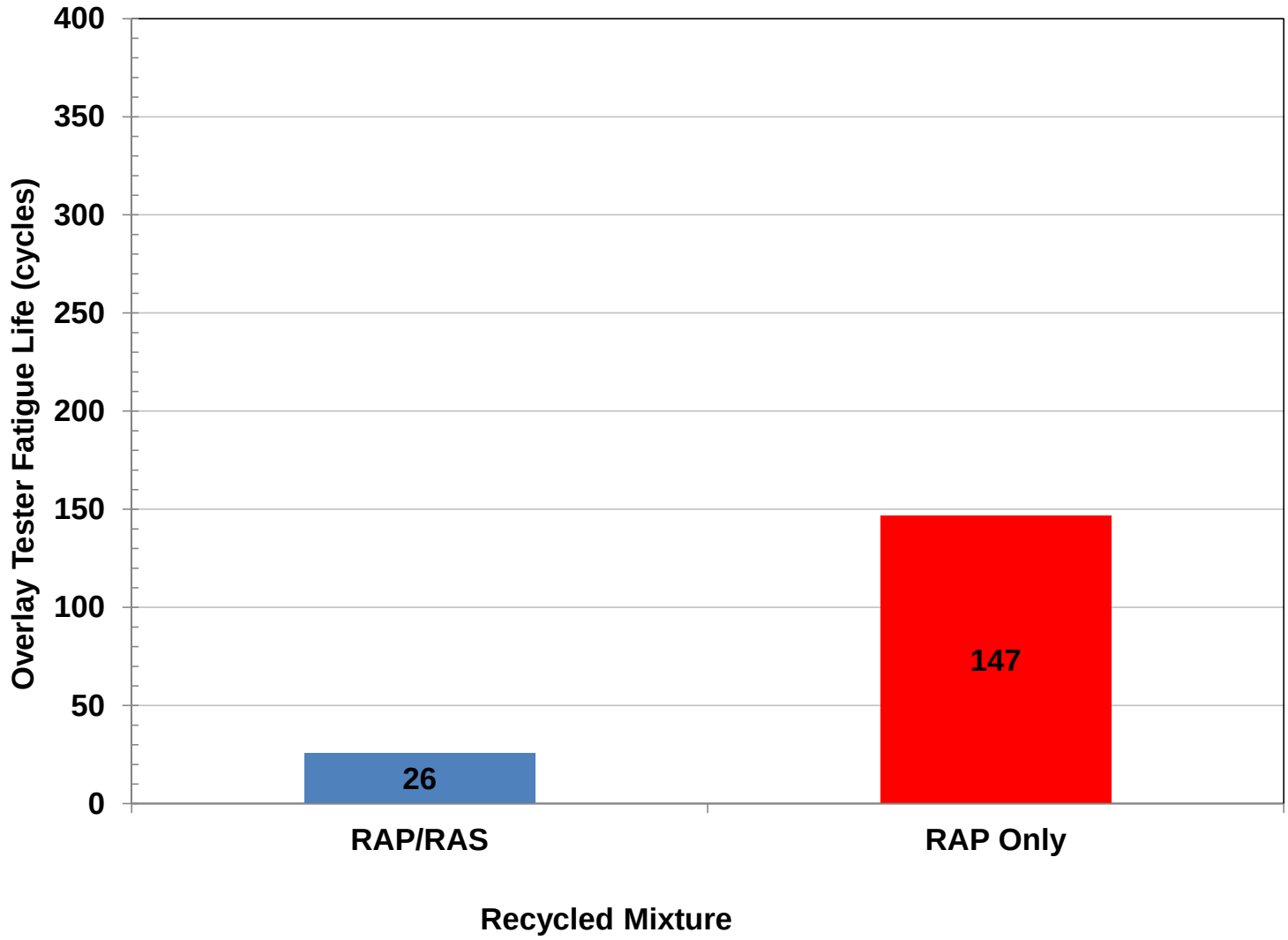
NYSDOT RAP/RAS Project

- Asphalt plant looking to begin using RAS. Comparing currently approved mix to RAP/RAS mixture
- RAP: 10% by weight of mixture
- RAP/RAS: 8% RAP/2% RAS by weight of mixture
- RAP Only: PG66.4-24.5; AC% = 6.3%
- RAP/RAS: PG75.0-21.4; AC% = 6.5%

NYSDOT RAP-RAS Project – Crack Initiation



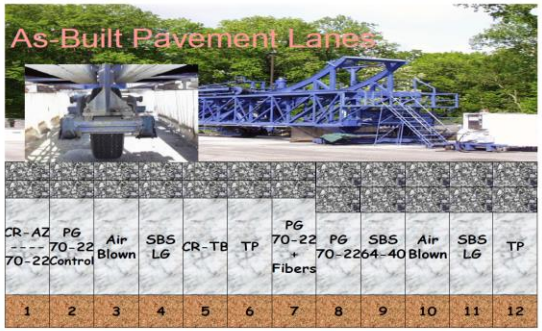
NYSDOT RAP-RAS Project – Crack Propagation



NYSDOT RAP/RAS Field Evaluation

- Longitudinal cracking starting in RAP/RAS section (2 Years)
- No cracking to date in RAP Only

FHWA's ALF Cracking Area vs Overlay Tester Results



CR-AZ = Crumb rubber asphalt binder, Arizona Department of Transportation (DOT) wet process

PG 70-22 = Unmodified asphalt binder control

Air Blown = Air-Blown asphalt binder

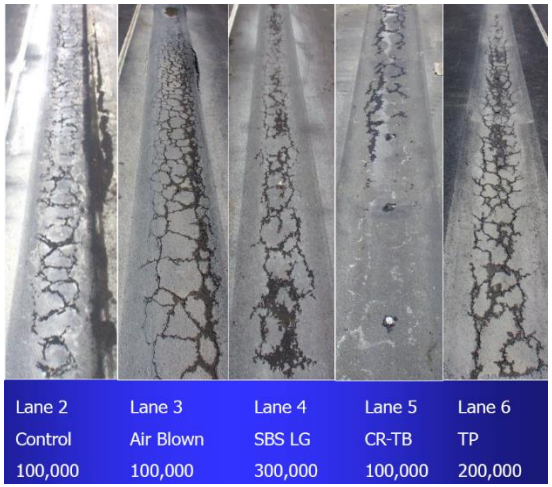
SBS LG = Styrene-Butadiene-Styrene modified asphalt binder with linear grafting

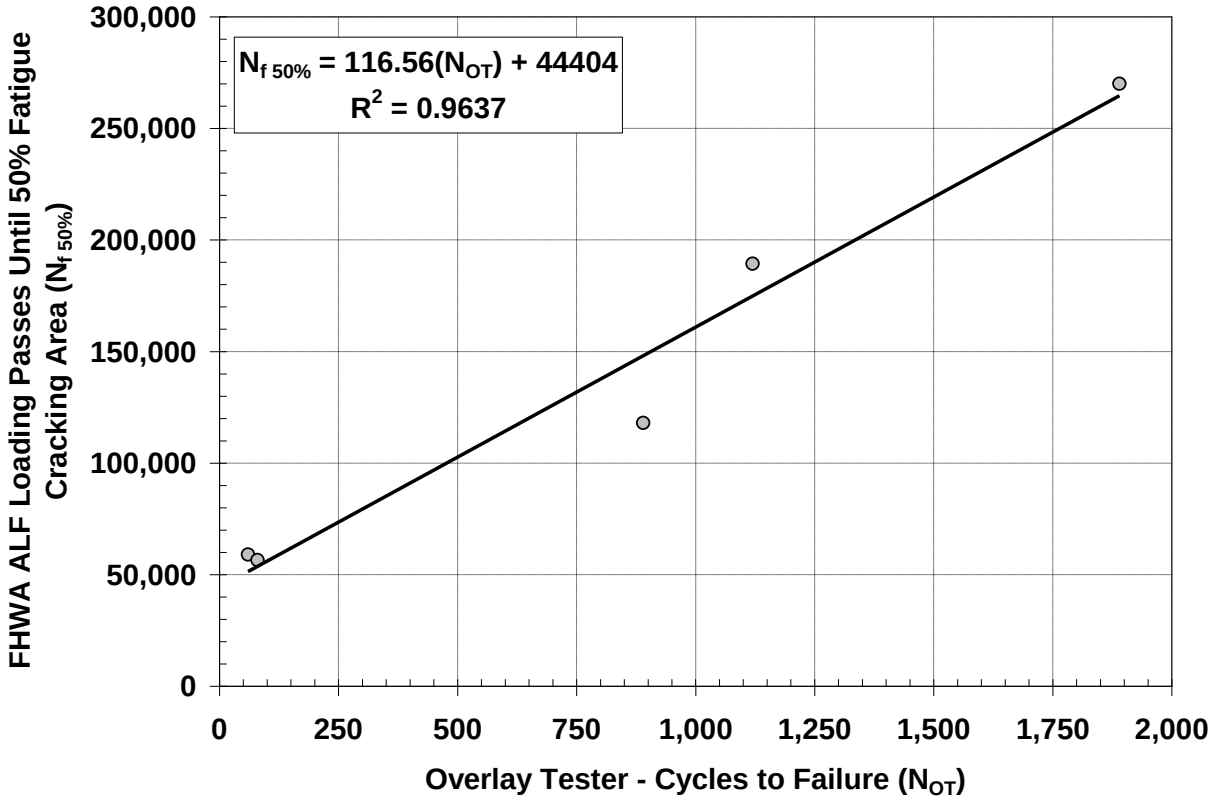
CR-TB = Crumb rubber asphalt binder, Terminal Blend

Terpolymer = Ethylene Terpolymer modified asphalt binder

Fiber = Unmodified PG 70-22 asphalt binder with 0.2 percent polyester fiber by mass of the aggregate

SBS 64-40 = Styrene-Butadiene-Styrene modified asphalt binder graded PG 64-40





Why Overlay Tester?

- Research shows that the Overlay Tester is capable of measuring the mixture's resistance to crack growth
  - Correlated extremely well to NJ's SPS-5 Sections
  - Something fundamentally different between virgin mixes and RAP mixes
    - Aged asphalt binder; lack of blending between old and new; under-asphalted condition
- Historical database of mixtures with varying RAP contents shows that the addition of only 15% RAP reduces the Overlay Tester fatigue resistance by 67%

Positive Steps to Achieving the NJDOT HRAP Specification

Know Your RAP

Know Your RAP Properties

- Recommend to produce a separate stockpile for use in the HRAP project. Better consistency with:
  - Asphalt content
  - PG Grade
  - Gradation
  - Fractionating?

Know Your RAP – Supplier #1 RAP Binder Grade & AC%

	High Temp	Low Temp	AC%
Sample #1	83.3	-17.4	4.3%
Sample #2	82.4	-19.0	5.1%
Sample #3	83.9	-17.0	4.3%
Sample #4	85.9	-14.6	4.6%
Sample #5	87.1	-17.7	3.8%
Average	**84.5**	**-17.1**	**4.4%**
Max	**87.1**	**-14.6**	**5.1%**
Min	**82.4**	**-19.0**	**3.8%**
Range	**4.7**	**-4.4**	**1.3%**

Know Your RAP – NJ Supplier's RAP Binder Grade

	High Temp	Low Temp	AC%
Supplier #1	84.5	-17.1	4.4%
Supplier #2	86.0	-16.8	4.7%
Supplier #3	92.3	-13.3	4.3%
Supplier #4	84.5	-19.7	5.0%
Average	**86.8**	**-16.7**	**4.6%**
Max	**92.3**	**-13.3**	**5.0%**
Min	**84.5**	**-19.7**	**4.3%**
Range	**7.8**	**-6.4**	**0.7%**

Ignition Correction for RAP

Ignition Correction for RAP

- At low RAP contents, errors with ignition oven correction factor produces minor differences.
- At higher RAP contents, larger impact on mixture binder content occurs

Collected PANYNJ Data – RAP AC%

	Extracted	Ignition	Diff. (or Correction Factor)
Plant #1	5.75%	6.99%	-1.24%
Plant #2	4.62%	5.31%	-0.69%
Plant #3	5.27%	6.17%	-0.90%
Plant #4	4.38%	5.46%	-1.08%
Plant #5	5.43%	6.25%	-0.82%

Average = -0.88%

HRAP Scenario

- NJDOT specifies RAP by weight of mix and not by total binder replacement
- General HRAP Scenario
  - Target AC% = 5.5%
  - RAP AC% (from solvent extraction) = 4.75%

HRAP Target AC% - Virgin and RAP Binder Contribution				Change in AC% Required
% RAP	% Virgin AC	% RAP AC	Total AC%	
0	5.50	0.00	5.50	+0.00
10	4.95	0.48	5.43	+0.08
15	4.68	0.71	5.39	+0.11
20	4.40	0.95	5.35	+0.15
25	4.13	1.19	5.31	+0.19
30	3.85	1.43	5.28	+0.23
35	3.58	1.66	5.24	+0.26
40	3.30	1.90	5.20	+0.30
45	3.03	2.14	5.16	+0.34
50	2.75	2.38	5.13	+0.38
55	2.48	2.61	5.09	+0.41
60	2.20	2.85	5.05	+0.45
65	1.93	3.09	5.01	+0.49
70	1.65	3.33	4.98	+0.53
75	1.38	3.56	4.94	+0.56

Example: HRAP Mix AC Differences

- Issue with mix passing fatigue requirement
- Conducted solvent extraction/recovery on tested APA samples
  - PG Grade 76.7 – 27.3
  - Asphalt Content = 4.88%
  - Ignition Oven AC% = 5.48%
    - NJDOT Verification = 5.47%
  - **Difference = -0.6%**

HRAP Ignition Oven Correction

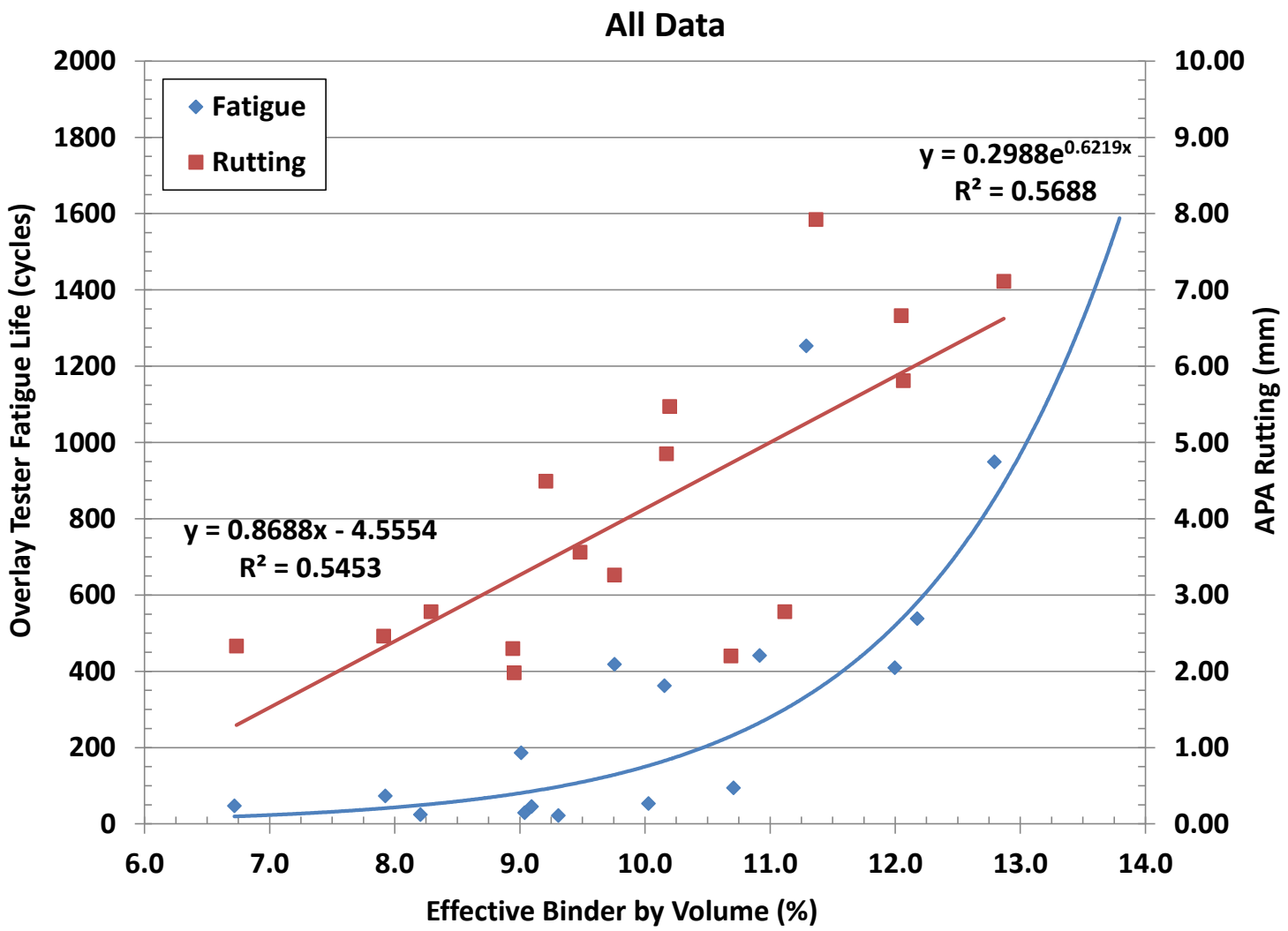
- The ignition oven correction factor should actually be a composite of two factors
  - Aggregate correction factor from the virgin mix
  - Correction factor of RAP ($AC\%_{Ignition} - AC\%_{Solvent}$)

Increasing Effective Asphalt Content

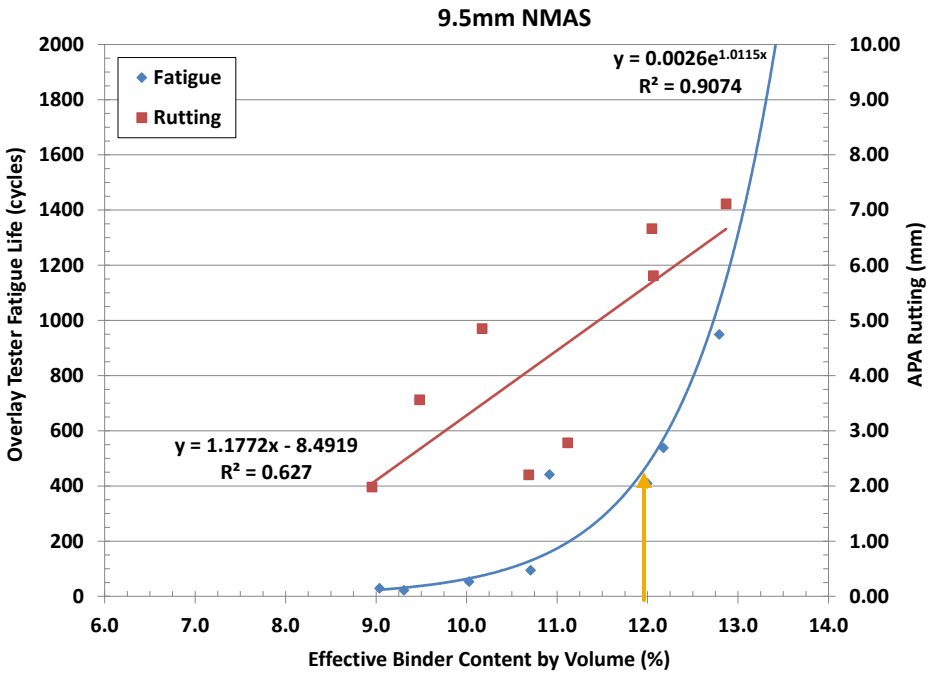
Increasing Effective Asphalt

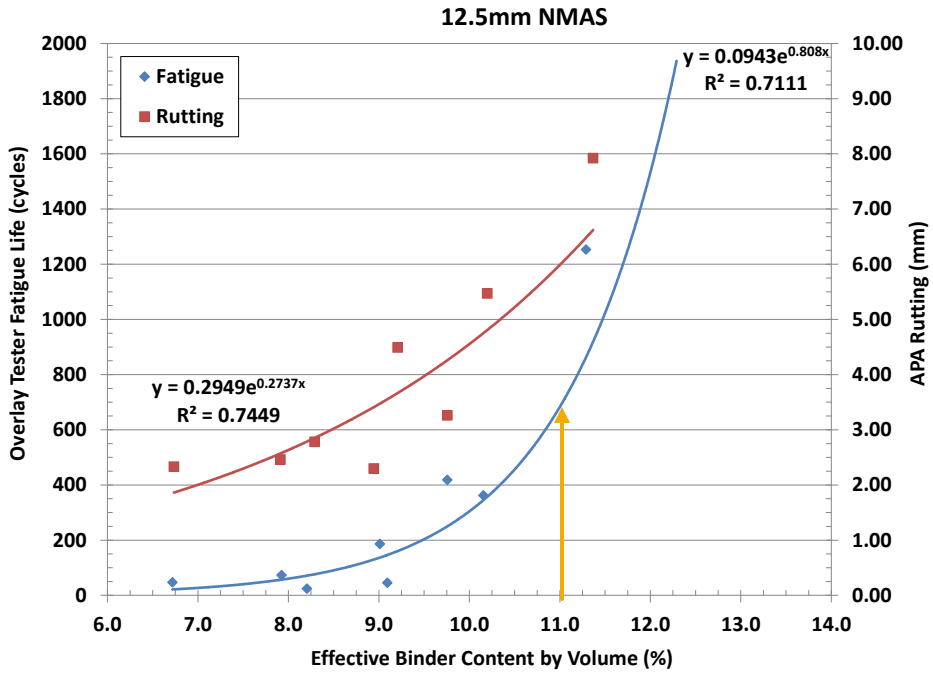
- NJDOT has increased minimum VMA to help increase effective asphalt content
  - Effective AC (by Vol.) = VMA – Air Voids
- Large amount of research shows that as the effective asphalt content increase, the fatigue resistance/durability increases
- Recommended Effective AC (by Vol)
  - 9.5mm: 12.5% (i.e. – VMA > 16.5%)
  - 12.5mm: 11.5% (i.e. – VMA > 15.5%)

Effective Binder Content by Volume (%) vs Performance



Effective Binder Content by Volume (%) vs Performance





Keep Your Options Open

Keep Your Options Open

- What has worked to date?
  - 1 Mix – Increased Effective AC using PG64-22
    - Completely different gradation than typical mixes
  - 1 Mix – PMA/Effective AC
  - 1 Mix – Rejuvenator
  - 1 Mix – Rejuvenator/WMA additive
- Final "solution" depends on producers' preference, capabilities, and materials


Thank you for your time!
Questions?
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